plane which contains the axis of rotation) to any required distance from the axis. The two arms meet each other at an angle of 45°.

From the form and arrangement of the internal pools (see fig. 1) it is evident that whenever the screw *e* is in contact with any of the pools *b*, *b*, *b*, *b*, the screw *f* must be in contact with the pools *a*, *a*, *a*, *a* (see fig. 2), and further inasmuch as *f* is nearer the axis than *e*, the times at which *e* makes and breaks contact with the pool *b* must respectively precede and follow those at which contact with the pool *a* is made and broken by *f*. Consequently the time during which both are in contact (*i.e.*, during which the circuit G G′ is closed) is determined solely by the duration of the immersion of *f*, and can be varied by altering its distance from the centre.

When it is desired to use the rheotome for investigating the effects of series of excitations recurring at short intervals (tetanus of muscle or nerve), all the pools are equally filled with mercury.

Their equality must be tested by interpolating each set of pools in the circuit of a Grove's cell, which also includes a recording chronograph; if the chronographic record shows that the durations of the contacts are not perfectly equal, the error must be corrected by adding or subtracting mercury. For investigating the effects of single excitations, only one of the external and one couple of the internal pools are used.

The drawing (fig. 2) shows the arrangement of the apparatus as used in the investigations made by Mr. Page and myself of the electrical phenomena of the ventricle of the heart of the frog. The instrument is set so that the external contact *g* is broken at a moment which immediately precedes the immersion of *f*: consequently the galvanometer circuit *G G′* is open at the moment of excitation, but closed immediately after, remaining closed so long as *f* is immersed. By means of the tangent screw, the interval between the opening of the exciting circuit *B B′*, and the closing of the galvanometer circuit *G G′*, can be varied at will.

III. "On the Chemical Composition of Aleurone-Grains." By S. H. VINES, M.A., D.Sc., Fellow of Christ's College, Cambridge. Communicated by MICHAEL FOSTER, M.D., Prælector of Physiology in Trinity College, Cambridge. Received April 1, 1880.

In a former communication ("Proc. Roy. Soc.," vol. 28, p. 218) I gave an account of an investigation of the aleurone-grains of the blue lupin. The following is an abstract of the results arrived at by the investigation of the grains of some other seeds by the same methods:—

II. *The Aleurone-Grains of the Peony* (Pæonia officinalis).

a. Microscopical Observations.—In accordance with the researches of Pfeffer ("Jahrb. f. wiss. Bot.," viii, 1872), the grains were found to be readily soluble in distilled water, the only proteid substance remaining in the cells being the matrix, which, like that of the lupin, is insoluble in dilute acids and alkalies. They also dissolve in 10 per cent. and in saturated NaCl solutions. Their solubility is unaffected by previous treatment with either ether or alcohol.

b. Chemical Observations.—The watery extract of the seeds (which has only a very faint acid reaction if a relatively large quantity of water is used) becomes turbid on boiling, and it gives all the reactions of a fluid holding proteid substance in solution. If it be boiled, evaporated to small bulk, and then filtered into alcohol, a dense precipitate is formed. The substance precipitated readily dissolves in distilled water, and the solution gives the reactions characteristic of a solution of peptones. The substance does not dialyse. It is probable, therefore, that it is identical with the soluble proteid detected in the seeds of the lupin, which I provisionally termed Hemialbumose.

This substance is readily precipitated from its watery solution by the addition of a small quantity of acetic acid. The precipitate differs, however, from the original substance in that it is only slightly soluble in distilled water: it is more soluble in solutions of alkaline carbonates, and it dissolves completely in dilute solutions of the alkalies. In this respect it resembles acid-albumin (syntonin).

If the seeds, after extraction with water until the filtrate gives only a very faint xanthoproteic reaction, be treated with 10 per cent. NaCl solution, a fluid is obtained which gives a dense precipitate on boiling, a precipitate on dilution with water, and on saturation with NaCl.

Further, if the seeds be extracted with saturated NaCl or $MgSO_4$ solution, a fluid is obtained which gives a slight turbidity on boiling, but no perceptible turbidity on dilution.

From these observations, it appears that the aleurone-grains of the peony consist of one proteid soluble in water (hemialbumose), and of another, insoluble in distilled water, but soluble in 10 per cent. NaCl solution, and precipitable from its solution by boiling or by saturation. This latter body corresponds in these respects with the substance found in the seeds of the lupin, and termed vegetable myosin.

It seems probable that the grains of the peony contain no substance (or, at most, a very small quantity of it) analogous to the vegetable vitellin, which occurs in the grains of the lupin, and which is soluble in saturated NaCl solution.

III. *The Aleurone-Grains of the Castor Oil Plant* (Ricinus communis).

a. Microscopical Observations.—When mounted in alcohol, the grains

are seen to be ovoid bodies which present no indication of a complex structure; occasionally a rounded mass may be distinguished at the more pointed end.

On the addition of water, the whole grain increases in size and becomes clearer, in consequence, apparently, of the solution of a part of its substance. It is then seen to consist of the rounded mass before mentioned, the globoid, and of a large crystalline body, the crystalloid, which are imbedded in a more or less spherical mass of proteid ground-substance.

The action of water is not affected by previous treatment of the grains with either alcohol or ether. The following results show that the solvent action of NaCl and $MgSO_4$ solutions is profoundly modified by such treatment.

1. Grains treated with ether:—

a. The ground-substance dissolves readily in 10 per cent. NaCl solution, and partially in saturated NaCl or $MgSO_4$ solution.

β. The crystalloid dissolves very slowly in 10 per cent. NaCl solution, but it is quite insoluble in saturated NaCl or $MgSO_4$ solution.

γ. The whole grain dissolves readily in 20 per cent. NaCl or $MgSO_4$ solution.

2. Grains treated with alcohol (or with alcohol and ether):—

a. The ground-substance dissolves readily in 10 per cent. NaCl solution, and partially in saturated NaCl or $MgSO_4$ solution.

β. The crystalloid dissolves slowly in 10 per cent. NaCl solution, but entirely and at once in saturated NaCl or $MgSO_4$ solution. If the grains, after treatment with alcohol, be washed with water, the crystalloids lose their solubility in saturated NaCl or $MgSO_4$ solution, but regain it on further treatment with alcohol.

γ. Both the ground-substance and the crystalloid dissolve very readily in 20 per cent. NaCl and $MgSO_4$ solutions; the crystalloid dissolves more readily after treatment with alcohol than it does after treatment with ether only.

b. *Chemical Observations.*—If crushed seeds be treated with water, after the oil has been extracted from them by alcohol or ether, a fluid is obtained which gives a precipitate on boiling. The filtrate, after evaporation to small bulk, gives a precipitate on being poured into alcohol. The substance precipitated is readily soluble in distilled water; the solution gives the reactions characteristic of a fluid holding peptone in solution. The substance does not dialyse. In these particulars it resembles the substances found in the seeds of the lupin and of the peony, and it may therefore be also termed hemialbumose. It is probably this substance which is seen to be dissolved when the grains are treated with water under the microscope.

1. Seeds treated with ether:—

a. When extracted with 10 per cent. NaCl solution, a fluid is

obtained which gives a precipitate on boiling, on dilution with water, and on saturation with NaCl; the supernatant saturated NaCl solution also gives a precipitate on boiling.

β. When extracted with saturated NaCl solution, a fluid is obtained which gives a precipitate on boiling and on dilution.

2. Seeds treated with alcohol (or with ether and alcohol):—

a. Extracted with 10 per cent. NaCl solution, a fluid is obtained which gives a precipitate on boiling, on dilution, and on saturation; the supernatant saturated fluid gives a precipitate on boiling and on dilution.

β. Extracted with saturated NaCl solution, a fluid is obtained which gives a precipitate on boiling and on dilution.

From these observations it appears that the ground-substance consists of hemialbumose and of two globulins, of which one is soluble and the other insoluble in saturated solution of NaCl or $MgSO_4$. The crystalloid consists of a globulin, which is soluble in 10 and 20 per cent. NaCl solutions, but insoluble in saturated NaCl solution; after treatment with alcohol it becomes soluble in saturated NaCl and $MgSO_4$ solutions.

Additional Remarks on the Aleurone-Grains of the Blue Lupin.

After the foregoing results had been obtained, it became necessary to complete the investigation of the grains of the lupin by ascertaining the action upon them of saturated NaCl and $MgSO_4$ solutions.

I found that the grains dissolved readily in both these fluids, and that their solubility was not affected by treatment with alcohol. The solution, in quantity, gives a precipitate on boiling and on dilution.

General Remarks.

The three kinds of aleurone-grains which have been investigated represent three degrees of complexity of composition. In the peony, the whole grain dissolves readily in water; in the lupin, the grain dissolves only partly in water, the residue being readily soluble in 10 per cent. NaCl solution; in Ricinus there is a morphological as well as a chemical differentiation; the ground-substance dissolves partly in water and partly in 10 per cent. NaCl solution, and in this respect it resembles the entire grain of the lupin, whereas the crystalloid dissolves very slowly in 10 per cent. NaCl solution.

It is by no means easy to give a satisfactory explanation of the entire solubility of the grains of the peony in distilled water, and of those of the lupin in saturated NaCl or $MgSO_4$ solution. In the grains of the peony the relative proportion of globulin to hemialbumose is apparently small, and it may perhaps be assumed that the neutral salts in the cells suffice to bring the globulin into temporary solution, so as to cause the entire disintegration of the grains. As regards the lupin, it is clear that the globulin of which the grains

principally consist is a vitellin, and possibly the formation of a precipitate which takes place during the saturation of the 10 per cent. NaCl solution may be attributed to a conversion of a part at least of the vitellin into a myosin.

In the course of my observations it became evident that alcohol, contrary to the generally received opinion, does not render the vegetable globulins insoluble in solutions of neutral salts.* All the abovementioned reactions are given by aleurone-grains which have been in alcohol for a very considerable time. The grains of Ricinus, for example, after having been in absolute alcohol for more than a year, give the same reactions as fresh ones. This is true of the globulins, not only whilst they exist in the form of aleurone-grains, but after their extraction; thus, the precipitate obtained by diluting a 10 per cent. NaCl extract of Ricinus seeds was quite soluble in 10 per cent. NaCl solution after having been for a month in alcohol.

The action of alcohol upon the crystalloids of Ricinus is remarkable in that it renders them readily soluble in saturated NaCl or $MgSO_4$ solution. That they are otherwise quite insoluble in these fluids is proved by the fact that I have kept quantities of crystalloids in excess of the saturated solutions for months; if some of these be treated for a few minutes with alcohol, they can be seen under the microscope to dissolve at once in these solutions. It is of interest to note that if, after treatment with alcohol, the crystalloids be washed with water, they lose their solubility in these saturated salt solutions, and that they only regain it after being again treated with alcohol. Alcohol appears, in this case, to convert a substance which is insoluble in saturated salt solutions into one which is soluble, that is, a myosin substance into a vitellin substance; and, from the foregoing facts, it seems that this conversion is closely connected with the removal of water from the substance.

These observations led me to investigate the crystalloids of a variety of plants with these reagents, and by the kindness of Dr. A. F. W. Schimper, of Strassburg, who has closely studied the subject ("Unters. üb. die Proteinkrystalloide," 1879), I was enabled to experiment upon the crystalloids which Professor Drechsel has succeeded in producing artificially from the proteids in the seeds of Bertholletia (Brazil nut) and of the pumpkin (Cucurbita) ("Journal f. Prakt. Chem.," 1879).

The results may be briefly stated as follows:—

A. Crystalloids insoluble in NaCl or $MgSO_4$ solution; *Musa Hillii*, *Musa Ensete*.

B. Partially soluble in NaCl or $MgSO_4$ solution; *Sparganium ramosum*.

* Radlkofer ("Ueb. Krystalle proteinartiger Körper," 1859) has already pointed out that alcohol does not cause the coagulation of the crystalloids of Ricinus, of Bertholletia, and of *Sparganium ramosum*.

C. Crystalloids entirely soluble in NaCl or $MgSO_4$ solution :—

a. Readily soluble in both 10 per cent. and saturated solutions, Bertholletia, pumpkin (Cucurbita), artificial crystals.

b. Slowly soluble in 10 per cent. solutions, more readily soluble in 20 per cent. solutions, soluble in saturated solutions only after treatment with alcohol, *Ricinus communis*, *Viola elatior*, *Linum usitatissimum*.

The crystalloids of *Musa Hillii* and of *Musa Ensete* (for this material also I am indebted to Dr. Schimper) are remarkable for their insolubility. They swell-up slightly, but do not dissolve in solutions of neutral salts of various degrees of concentration and in 1 per cent. Na_2CO_3 solution. They swell-up considerably, but do not dissolve in dilute HCl. They swell-up and dissolve partially in dilute KHO. They therefore, probably consist of some relatively insoluble albuminate.

When treated with 10 or 20 per cent. solution of NaCl or $MgSO_4$, the crystalloids of *Sparganium ramosum* swell-up considerably, and the central portion dissolves, leaving the external portion of the crystalloid as a thick-walled vesicle; on the addition of water, a granular precipitate is thrown down inside the vesicle. The process of solution is the same when the crystalloids are treated with 1 per cent. Na_2CO_3 solution, but dilution with water does not, in this case, produce a precipitate inside the vesicle. The central portion of the crystalloid dissolves also when they are treated with saturated NaCl solution, but the swelling-up is less considerable. The vesicle dissolves readily in dilute KHO, and in dilute (·4 per cent.) HCl. These crystalloids, therefore, consist of two substances, a vitellin, forming the central mass, and an albuminate, forming the outer portion. This albuminate may be probably regarded as having been produced by an alteration of the globulin of which the whole crystalloid doubtless consisted originally.

It appears that no definite relation exists between the crystalline form and the solubility of the crystalloids in solutions of neutral salts. According to Schimper (*loc. cit.*) all the crystalloids which I have examined belong to two systems, the regular and the hexagonal.

1. Hexagonal rhombohedra: crystalloids of Musa, Sparganium, Bertholletia, and the artificial crystals obtained from Bertholletia.

2. Regular tetrahedra: crystalloids of Ricinus, Viola, Linum, Cucurbita, and the artificial crystals obtained from Cucurbita.

In all cases I found the aleurone-grain to be invested by a peripheral layer (*Hüllmembran*), which is apparently insoluble, and which, as Pfeffer suggests, contributes to form the proteid network or matrix which remains in the cells after the more soluble portions of the grains have been dissolved out.

Whenever saturated solutions of NaCl were used, or when saturation with NaCl was necessary, for the purpose of separating myosin

from vitellin, I verified the results by using $MgSO_4$, in accordance with the researches of Hammarsten ("Ueb. das Paraglobulin," "Pflüger's Archiv," 1878).

In conclusion, I would add a few remarks to those which I made in my former communication with reference to the relation between the globulins and the hemialbumose existing in seeds and the various bodies, such as conglutin, legumin, &c., which Ritthausen has extracted from them. I therein expressed my concurrence with Weyl's opinion that these caseins are the products of the alteration of the globulins effected by the alkaline solutions used in extracting them. I still maintain this view, but I think now that it is only a partial explanation. My observations, more particularly those on the peony, make it clear that a considerable proportion of these caseins is hemialbumose precipitated by the dilute acetic acid which is used in Ritthausen's method for throwing down the caseins from the alkaline extracts.

IV. "Some Observations upon the Hydrolytic Ferments of the Pancreas and Small Intestine." By HORACE T. BROWN, F.I.C., F.C.S., and JOHN HERON, F.C.S. Communicated by Dr. W. ROBERTS, F.R.S. Received April 15, 1880.

We were requested a few months ago by Dr. W. Roberts to verify a statement, recently made by Musculus and De Méring, that *maltose* is a product of the action of an aqueous extract of pancreas upon starch-paste. During the prosecution of the inquiry, and while following up certain lines of experiment which suggested themselves from time to time, we have, besides fully confirming the results of the above-mentioned observers, ascertained certain facts which we believe are of some physiological importance in elucidating the still very obscure processes of animal digestion and nutrition.

I. *Hydrolytic Action of the Pancreas.*

The first observation upon the amylolytic action of the pancreatic secretion appears to have been made by Bouchardat and Sandras* in the year 1845. The general functions of the gland were more fully studied in 1856 by Claude Bernard,† and a few years later by Cohnheim ("Virchow's Archiv," 28, 241, 1863). Danilewski‡ in 1862, and Hüfner ("Journ. f. Prakt. Chem." [2], 5, 1872, 396), ten years later,

* "Des Fonctions du Pancréas, et de son Influence dans la Digestion des Féculents." "Compt. Rend.," 20, 1085.

† "Mémoire sur le Pancréas." 1856. "Leçons de Physiologie Expérimentale." Paris, 1856.

‡ "Ueber specifisch wirkende Körper des Natürlichen und Künstlichen Pancreatischen Saftes." "Virchow's Archiv," 1852, 25, 279.